Project ID # VAN023

Assessing the Energy and Cost Impact of Advanced Technologies of Light-Duty Vehicles

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Project Overview

Timeline	Barriers*
• Project start date : Oct FY18 • Project end date : Sep FY19 • Percent complete : 70%	• Risk aversion • Constant advances in technology • Cost • Computational models, design, and simulation methodologies *from 2011-2015 VTP MYPP
Budget	**Partners**
• FY19 Funding : $250K	• U.S. Drive Partners • Outside companies (OEMs, suppliers…)

Project Relevance

Quantify Impact of Individual Technologies Developed by Vehicle Technology Office

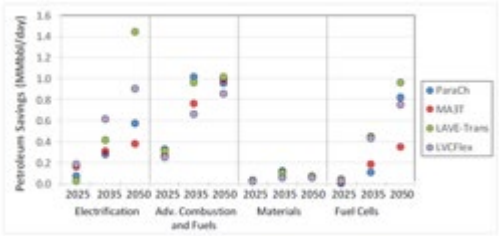
Current Process

Baseline & Individual Targets

Vehicle models combining ALL targets

AUTONOMIE

Overall VTO Program Benefits

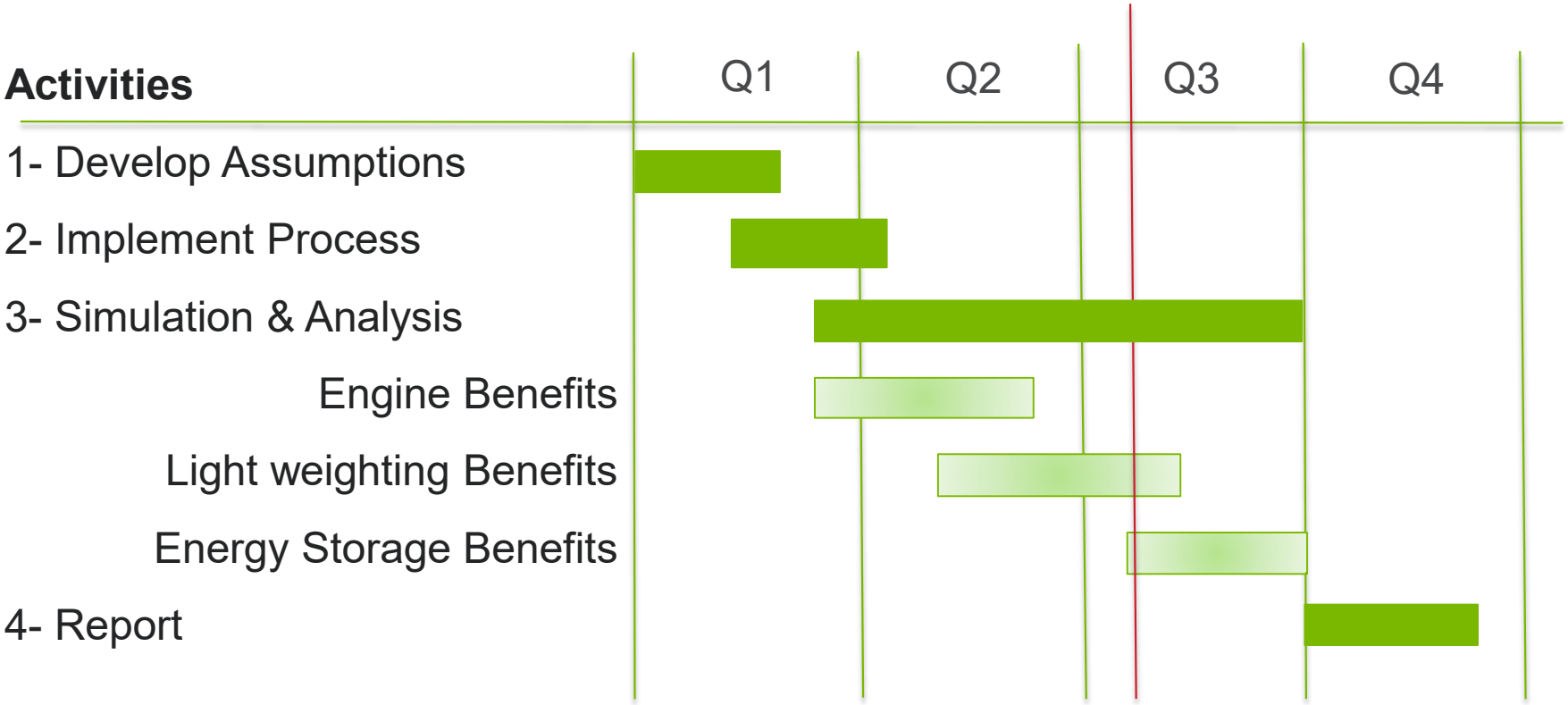


- ✗ Change baseline
- ✗ Individual technology benefit
- ✗ Technology synergies

New Process

- ✓ Overall VTO program benefit
- ✓ Individual component benefits
- ✓ Quantify synergies
- ✓ Compare impact to any technologies (different baselines)
- ✓ Represent >90% of the existing fleet

Milestones



Project on schedule and on budget

Approach

Build on existing large scale simulation process

Components

- VTO Technical Targets
- Performance
- Weight
- Cost
- …

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Powertrains

- Conventional
- Start-stop
- BISG
- HEV
- PHEV
- BEV
- FCEV
- …

×

Vehicle Classes

- Compact car
- Midsize car
- Small SUV
- Large SUV
- Pickup truck

Performance

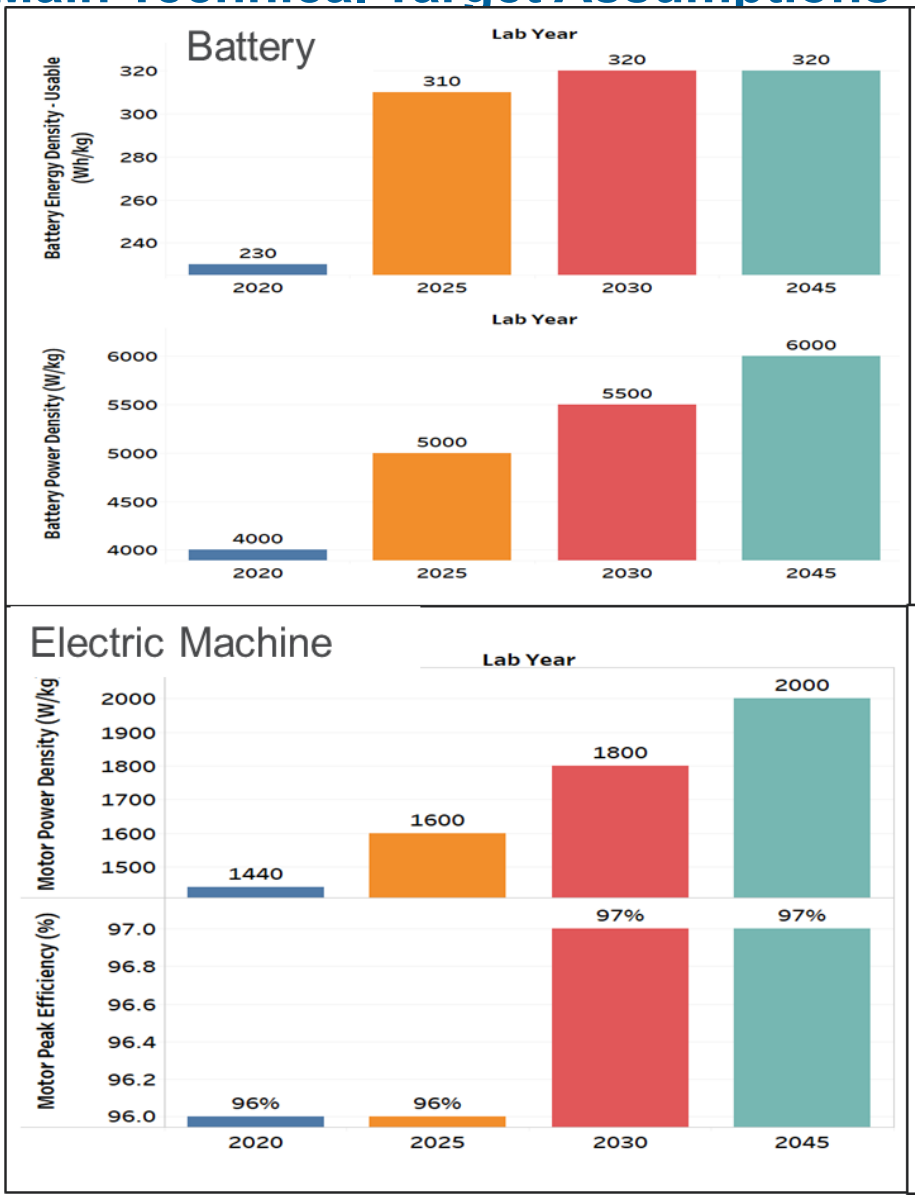
- 0-60 mph
- 50-80 mph
- Grade
- Towing…

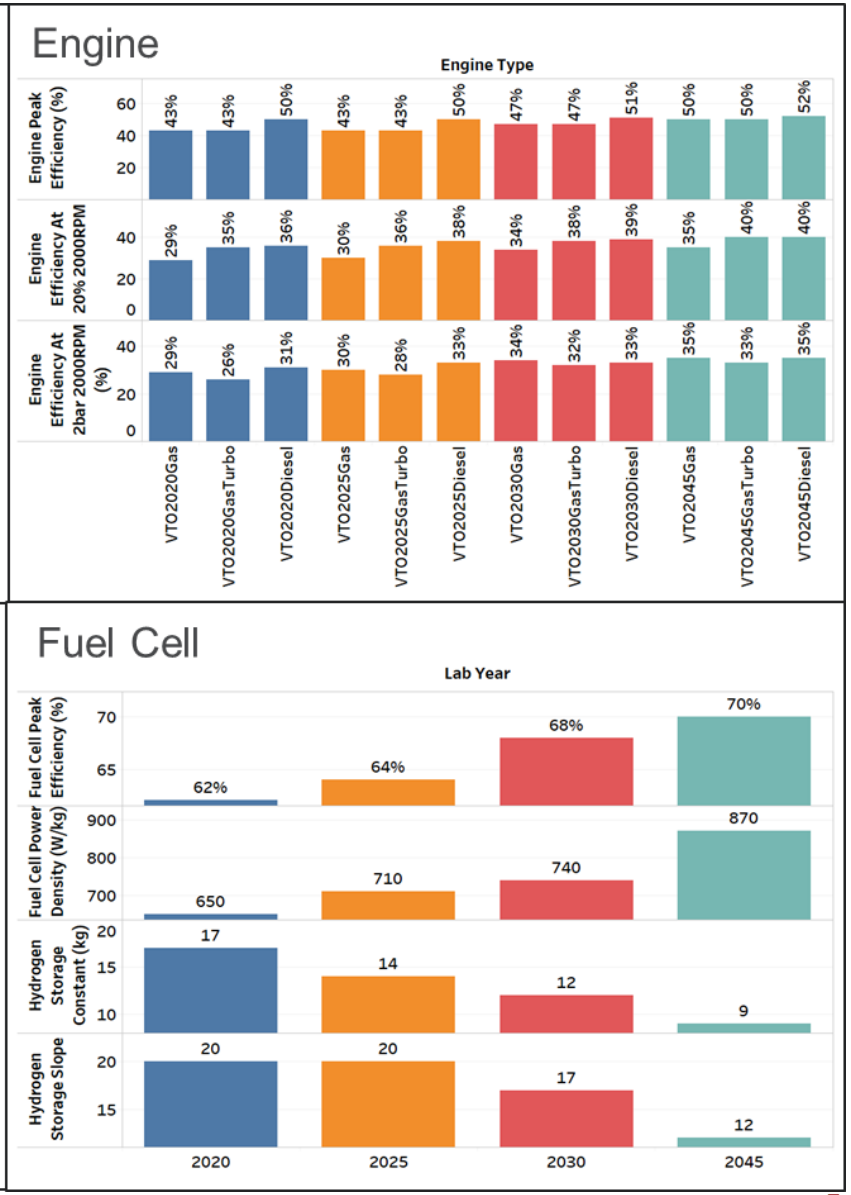
Size Powertrain & Run Standard Cycles

AUTONOMIE

Approach

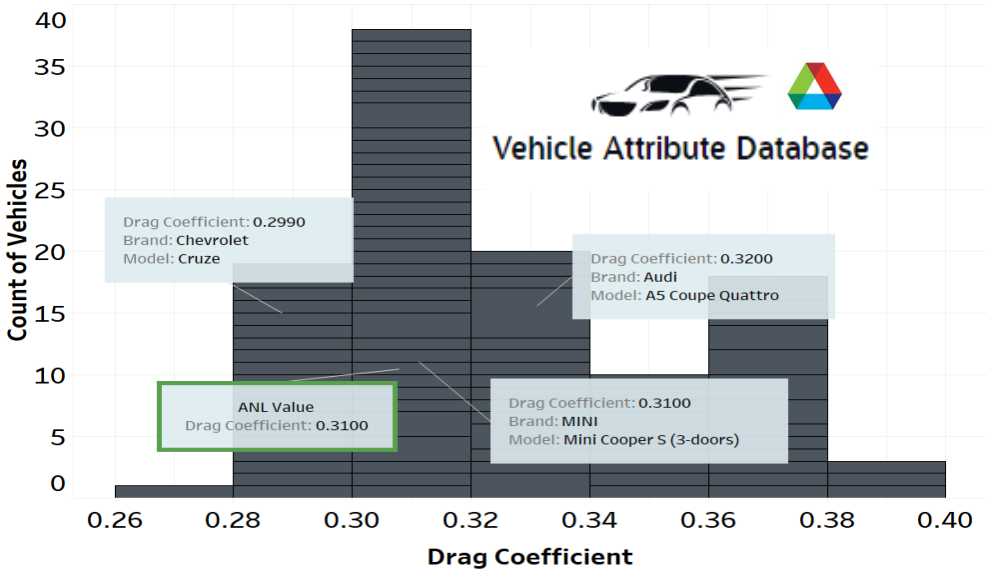
Main Technical Target Assumptions

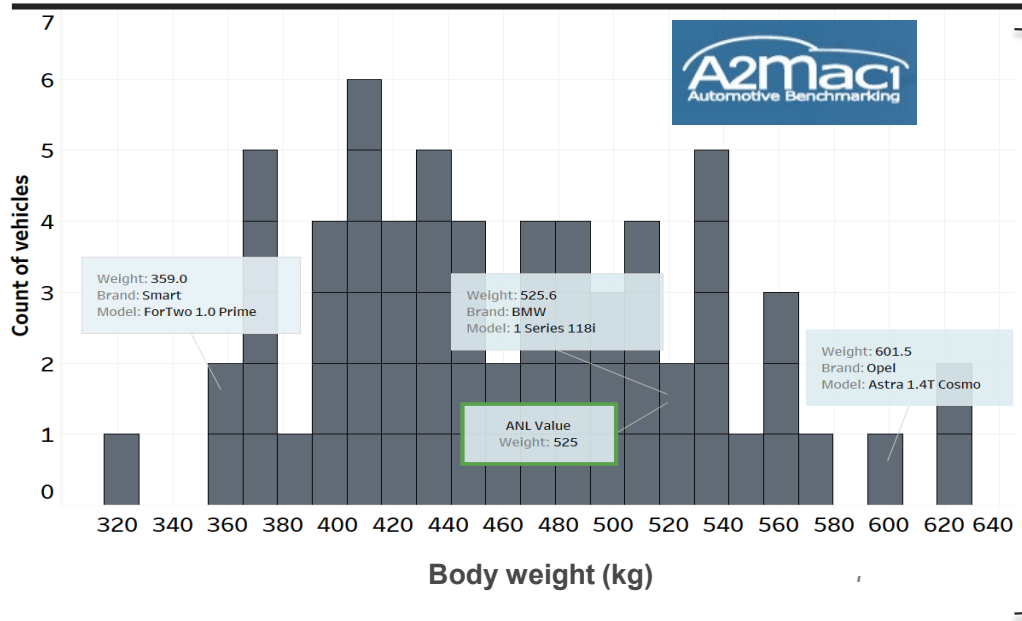




Technical Accomplishments

Updated Parameters for Baseline Vehicles Using Multiple Databases





Vehicle attributes:

- Frontal area
- Drag coefficient
- Rolling resistance
- Final drive ratio

Component weights:

- Body
- Chassis
- Safety
- Interior
- Gearbox
- Final drive

….

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Technical Accomplishment

Simulated Every Single Potential Technology and Their Combinations

Example – 2025 Naturally Aspirated Engine Target

Other Component Technologies

Transmissions
- Automatic
- Dual Clutch
- Manual
- Cont. Variable

Gear Numbers
Light weighting
Energy storage
Electric machine
Aerodynamic
Tires
…

Powertrains

Conv, start-stop, BISG, HEV, PHEV, BEV, FCEV

Classes

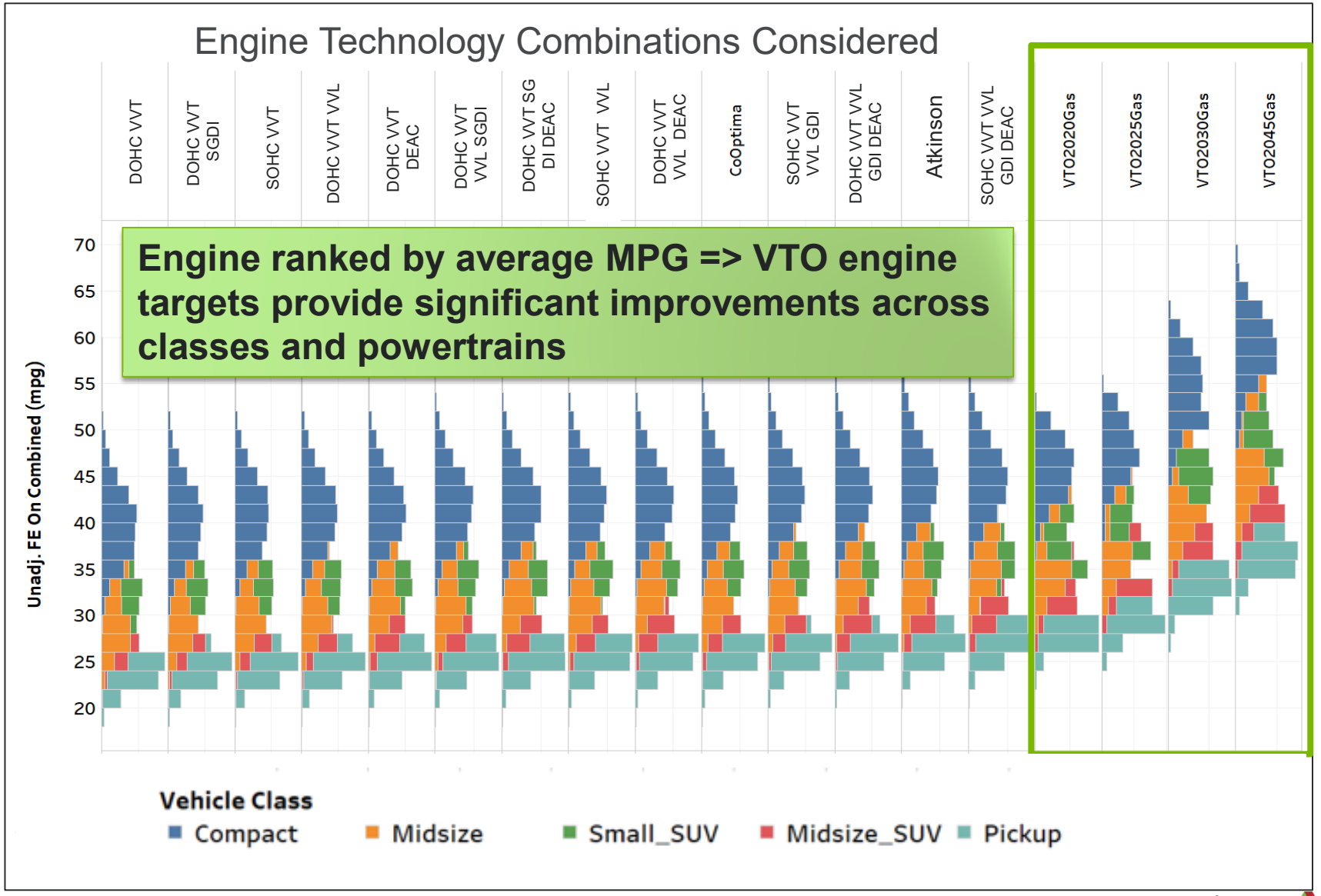
Cars (compact, midsize…), SUVs (compact, midsize…), pickup

Depending how the engine will be used, fuel economy ranging from 25 to 55mpg can be achieved

Unadjusted Fuel economy (MPG)
Combined EPA Cycle

Technical Accomplishments

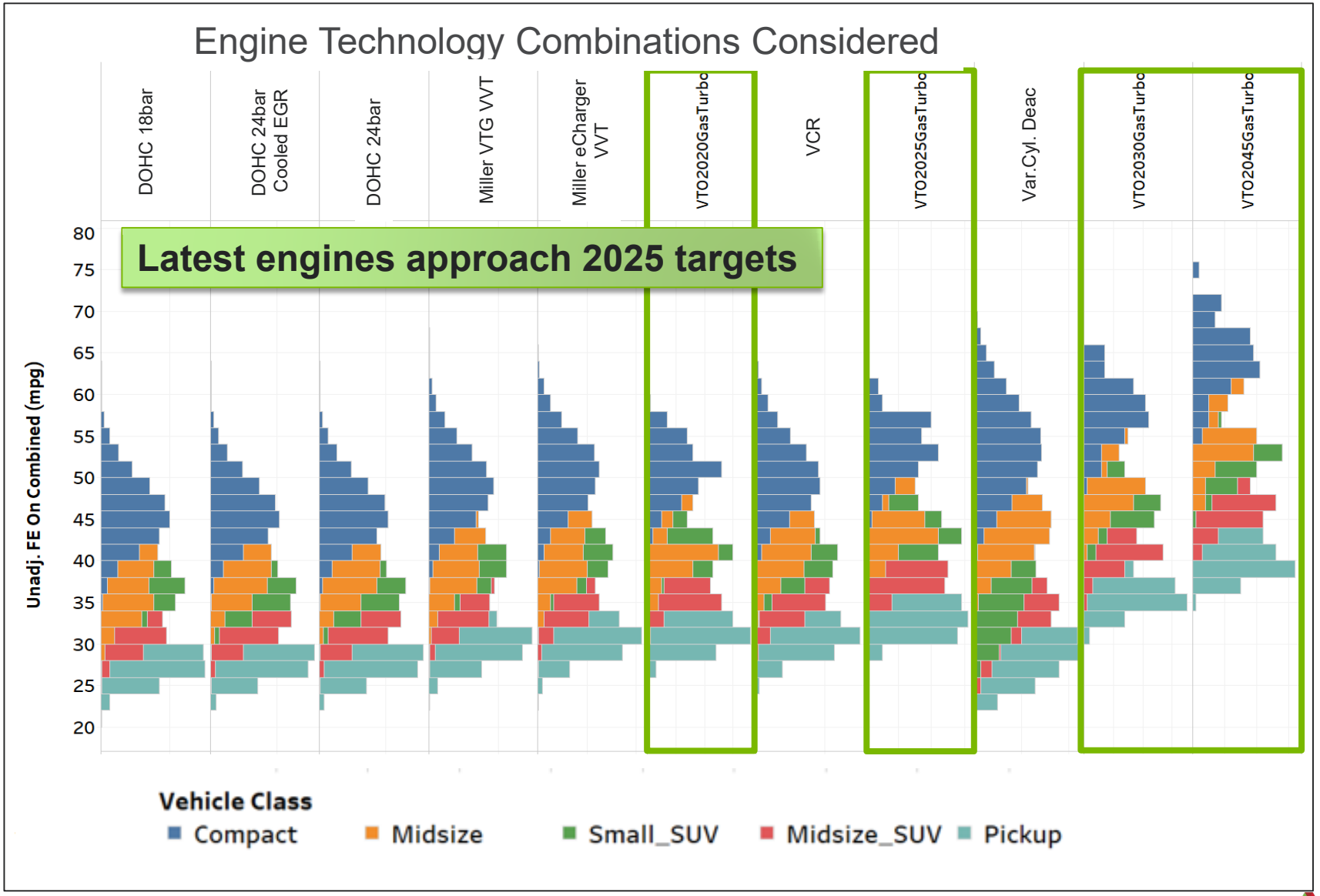
Quantified Naturally Aspirated Engines Technical Target Impacts



DOHC – Dual Overhead Camshaft
SOHC – Single Overhead Camshaft
VVT – Variable Valve Timing
VVL – Variable Valve Lift
DI – Direct Injection
Deac – Cylinder deactivation

Technical Accomplishments

Quantified Turbo Engines Technical Target Impacts

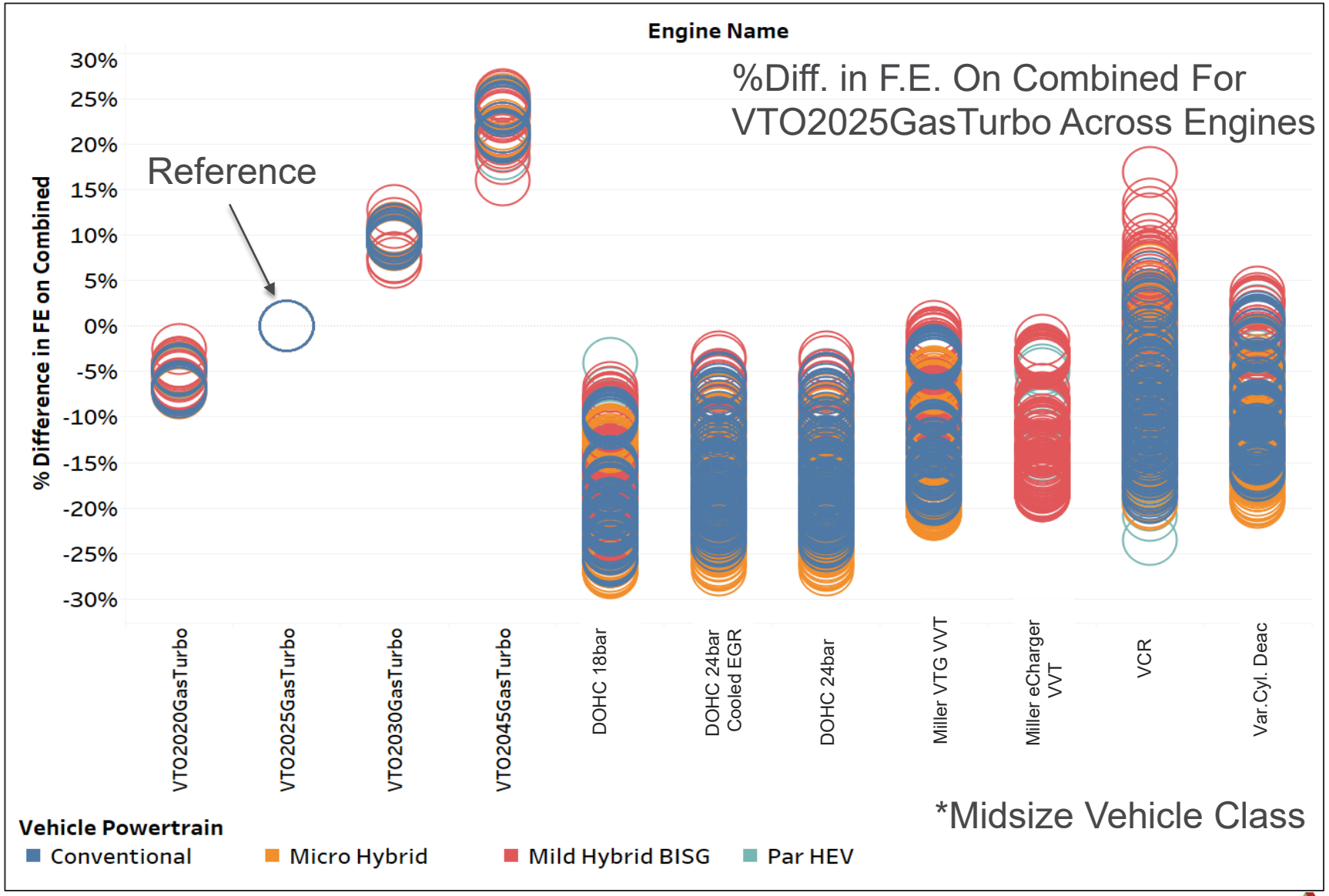


EGR – Exhaust Gas Recirculation
VCR – Variable Compression Ratio

eCharger – 48V turbo charger

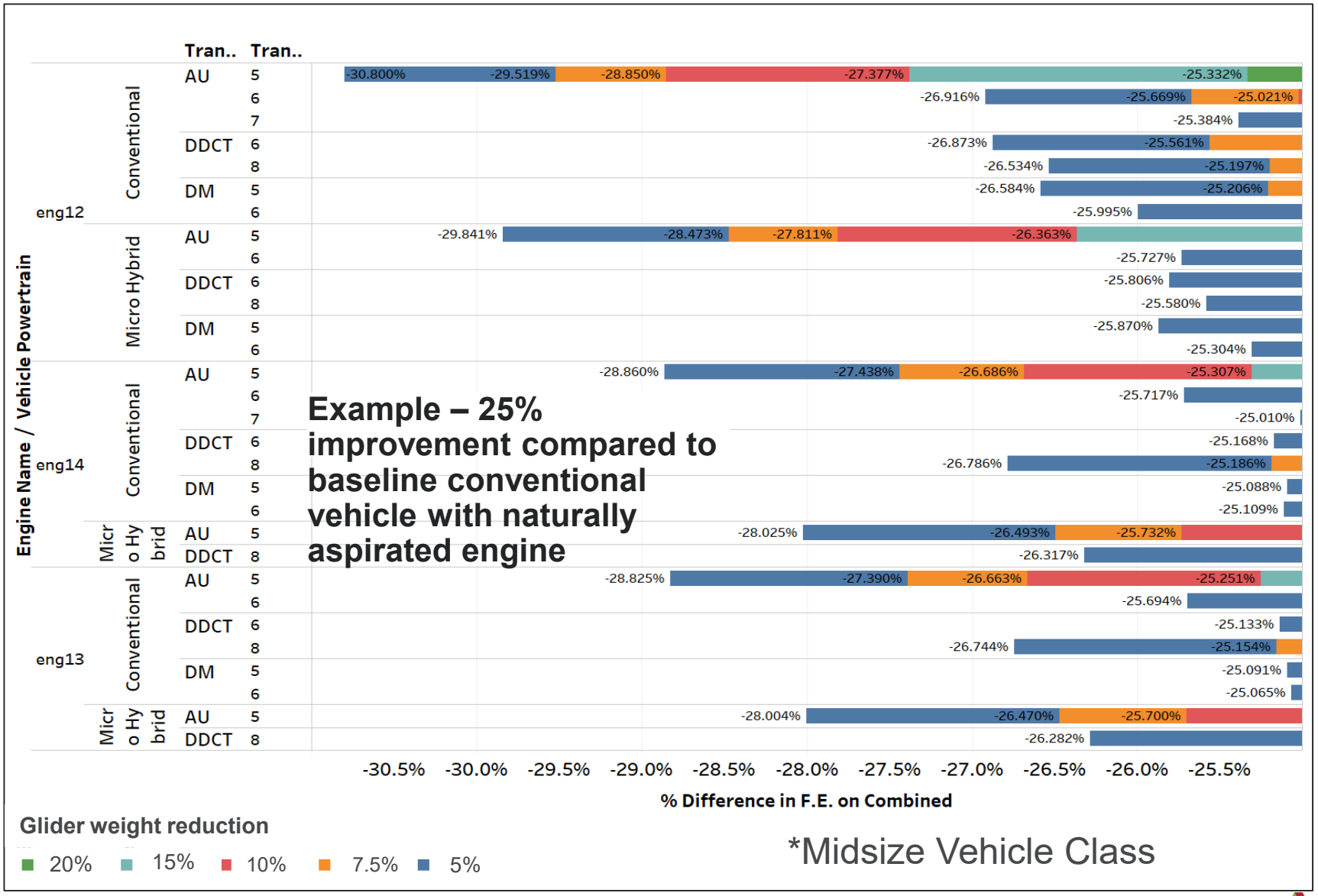
Technical Accomplishments

Engine Technology Impact Comparison



Technical Accomplishments

List Vehicle Combinations Meeting Specific Fuel Economy Improvements

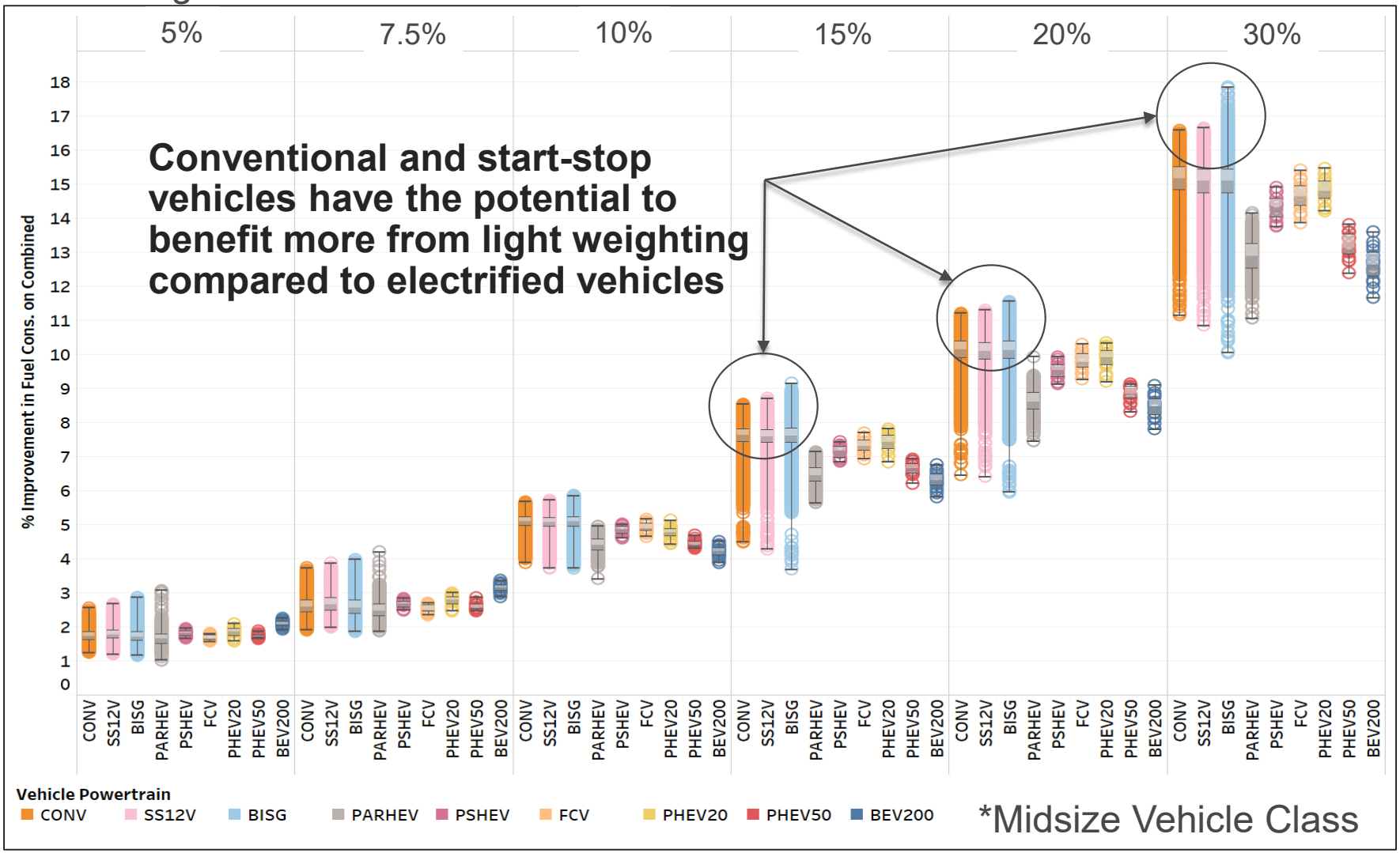


*Midsize Vehicle Class

Technical Accomplishments

Light weighing Impact Across Powertrain Configurations

Glider weight reduction



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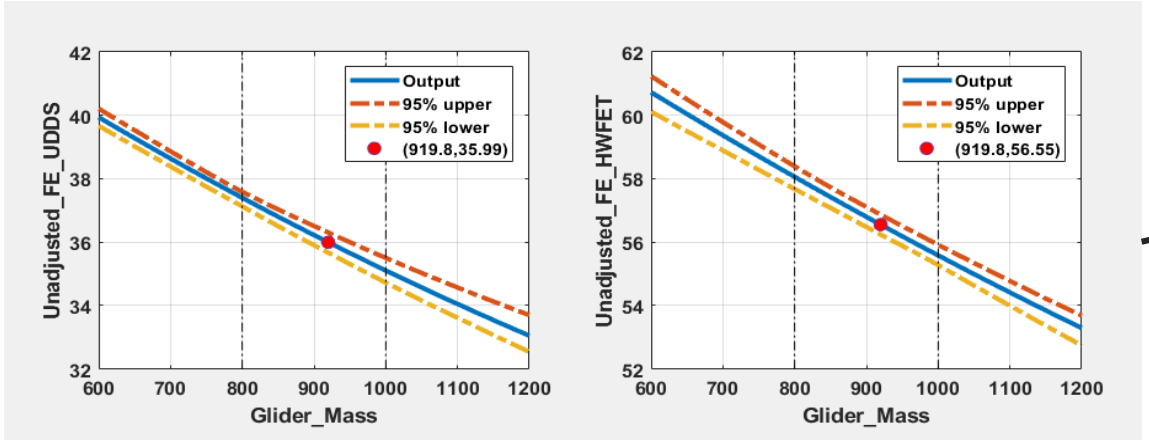
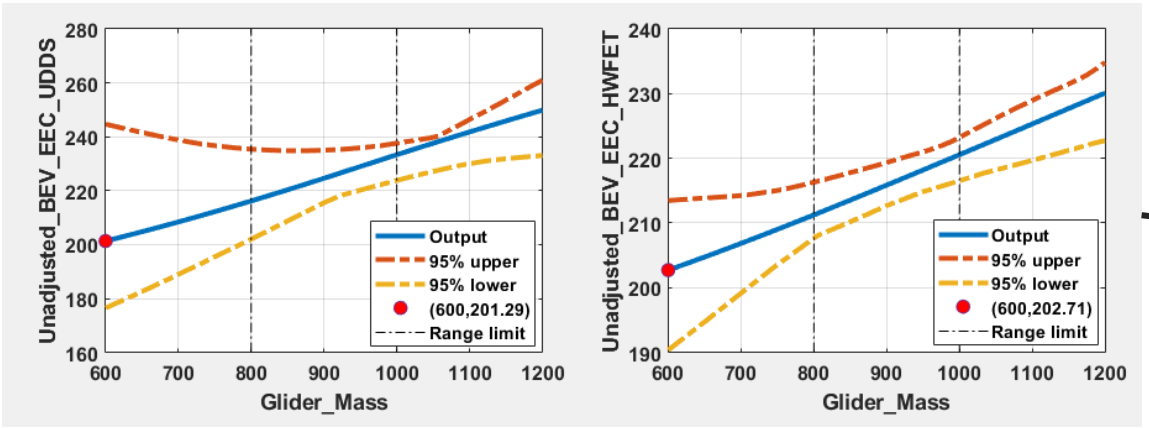
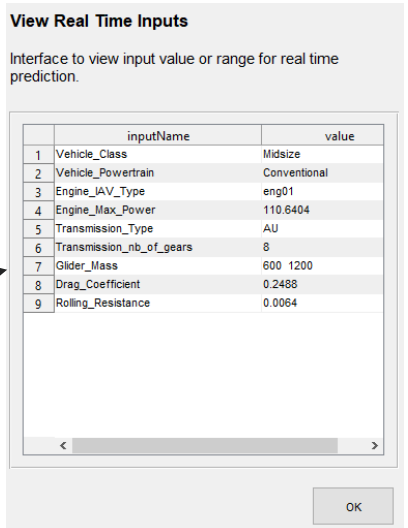
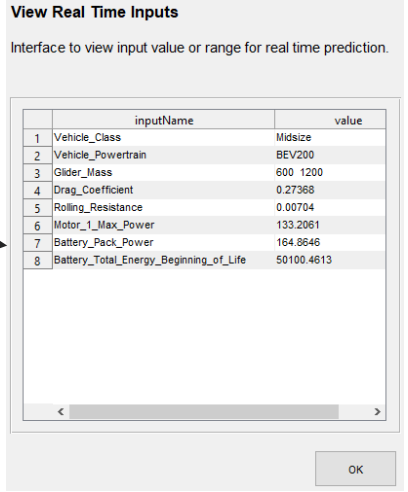
Technical Accomplishments

Developed Machine Learning Model to Estimate Light Weighting Impact









Collaborations

- Assumptions
  - IAV (GTPower engine performance data)
  - DOT / NHTSA
  - Inputs / feedback from several OEMs
- Process
  - Argonne High Performance Computing (HPC) experts
- Results
  - VTO Benefit Analysis project (VAN018)

Remaining Challenges and Barriers

- Evaluating component specific improvements increases the overall number of simulations by a few orders of magnitude.
  - Millions of simulations are carried out using HPC
- Need to include additional component technologies as they become available to the market
- Quantify the average impact of each individual technologies using statistical analysis
- Provide results as input to the existing VTO benefit analysis process

Future Work

Tasks	Motivations
Complete analysis of individual technical targets	Quantify the benefit of each individual R&D activity (battery, engine, light weighting..)
Analyze the impact of multiple targets and their potential synergies (e.g., engine and light weighting…)	Quantify the synergies between individual R&D activity (i.e., engine and light weighting)
Add costs for all vehicle component combinations	Estimate MSRP & levelized cost of driving
Add BatPaC(1) to the process	Improve battery pack design
Continue to improve Machine Learning model	Perform quick analysis without the need to always run full simulations
Disseminate results	Provide vehicle energy and cost to entire research community

(1) Battery design and cost model - http://www.cse.anl.gov/batpac/

Summary

- Historical process focused on assessing the impact of the entire VTO R&D portfolio on five vehicle classes compared to a single baseline vehicle.
- This study allows us to
  - Represent >90% of current vehicle technologies across 10 vehicle classes
  - Quantify the impact of one or more R&D activities (I.e., engine, engine with light weighting…)
  - Quickly update the analysis for different baselines (i.e., MY18 to MY19)
- Collaborative project that will be used to guide current & future R&D activities as well as provide support for further analysis (e.g., market penetration, GREET…)

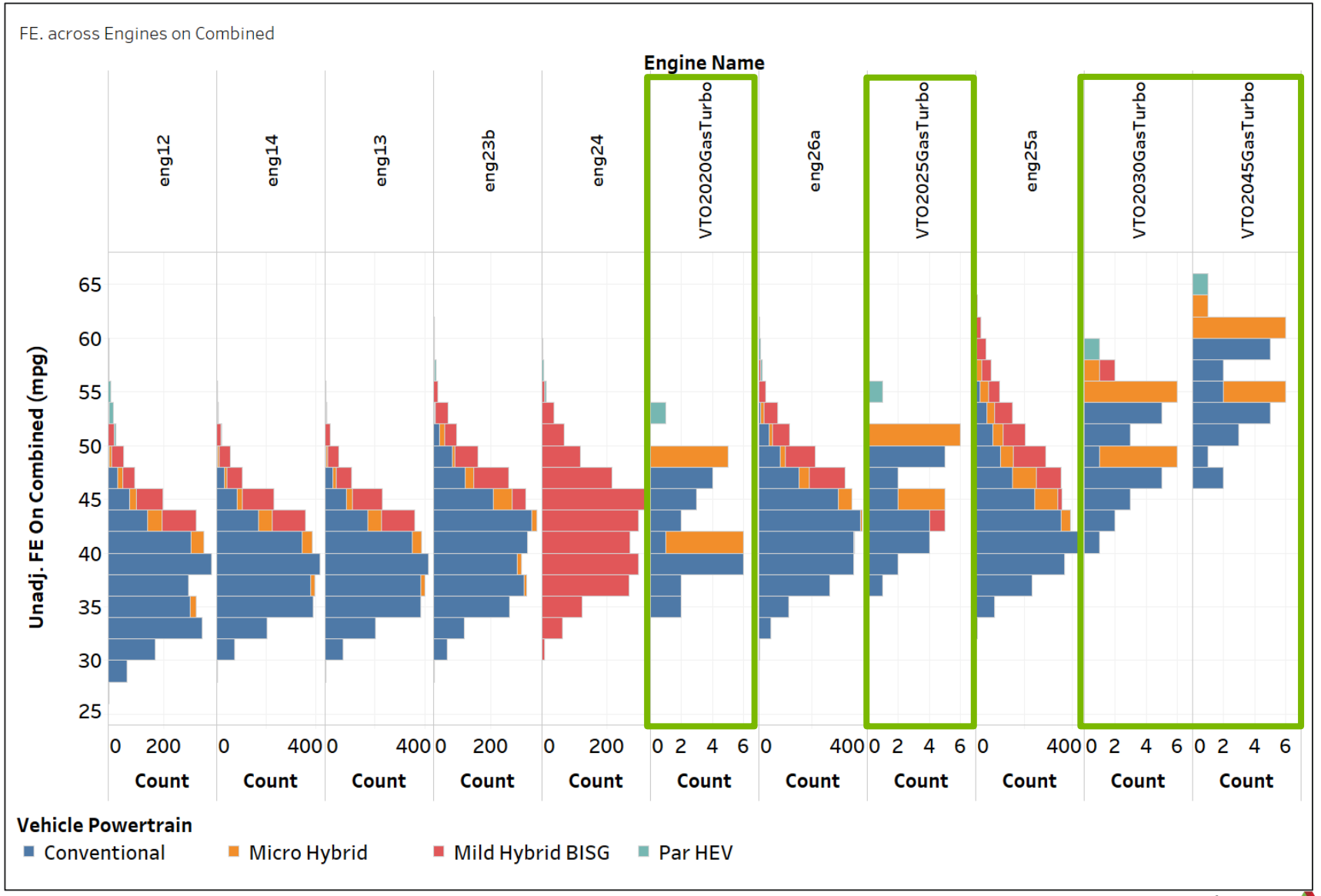
THANK YOU

Fuel Economy Across NA Engines on Combined (mpg)

Midsize Vehicle Class

Fuel Economy Across Turbo Engines on Combined (mpg)

Midsize Vehicle Class



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